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Working minimum temperatures for the design of glasshouse heating

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1. Introduction

1.1 It is essential to have information on minimum temperatures when designing a glasshouse heating system. The heating requirements are normally expressed in terms of temperature lift ie the difference between ambient temperature and the temperature the grower needs within the house, which will be determined by his cropping and management.

1.2 It is customary to use the lowest daily minimum temperature which has been recorded over the heating period for a number of years, or some related value. For example, Hogg (1966) has given for various periods the absolute minimum and the minimum temperature which provides the requisite lift in 4 years out of 5 ("safe" minimum temperature).

1.3 These lead to some apparently unduly high values for the lift and this note examines the possibility of adjusting them and also modifying our conception of minimum temperature in relation to glasshouse heating.

2. General considerations

2.1 The minimum temperature as normally recorded with an alcohol in glass thermometer provides only one item of information - the lowest temperature since the thermometer was set. It tells us nothing concerning the length of time for which the air was at that temperature, or at any other temperature, facts which could well be relevant to design problems.

2.2 It is reasonable to assume that the heat contained within the house itself (the piping, the structure and the growing plants) will supply a buffering against short periods at low temperatures. Our aim is to assess the amount by which the value of air minimum temperature used in designing heating systems could be raised without incurring undue risk on cold nights.

3. Method

3.1 Terminology. As mentioned in 1.2, the lift is at present determined either by the absolute minimum temperature or, more often, the safe minimum temperature. In place of a single value minimum temperature, we propose a working 3-hr minimum temperature defined as the highest of the three lowest consecutive hourly temperatures. The air temperature is therefore at or below that value for about three hours, the precise period being dependent on the shape of the temperature curve for that night. Similarly, we may define a working 5-hr minimum temperature but it is unnecessary to consider longer periods, as 5 hours is one-third the length of a winter night.

As minimum temperature is conventionally written T_n we may write the working 3 or 5-hr minimum temperatures respectively as 3hr T_n, 5hr T_n.

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3.2 Data and method

3.2.1 Hourly and daily minimum temperatures are recorded at Filton, nr Bristol, to 0.1°C. These were available for the period 1961 to 1970. Of these, the coldest nights were selected and the hourly values examined in detail. The examination was restricted to those nights on which T_n fell below -3.5°C, a total of 129 nights.

3.2.2 For each of the selected nights the following values were tabulated: T_n, 3hr T_n and 5hr T_n. These were expressed as (T_n - 3hr T_n) and (T_n - 5hr T_n), as shown in Tables 1 and 2.

3.2.3 Table 1 Distribution of (T_n - 3hr T_n) in relation to T_n

T_n	(T_n - 3hr T_n) 0-0.5	0.6-1.0	1.1-1.5	1.6-2.0	2.1-2.5	2.6-3.0	3.1-3.5	3.6-4.0	Totals
- 3.6 to - 4.5	5	4	20	5	3	1			38
- 4.6 to - 5.5	3	9	10	7	1				30
- 5.6 to - 6.5	6	10	8		1				25
- 6.6 to - 7.5	1	7	3	2	1			1	15
- 7.6 to - 8.5	3	2	6	1					12
- 8.6 to - 9.5			1	1	1				3
- 9.6 to -10.5	1								1
-10.6 to -11.5				1					1
-11.6 to -12.5			1						1
-12.6 to -13.5			1						1
-13.6 to -14.5				1	1				2
Totals	19	32	50	18	8	1	0	1	129

3.2.4 Table 2 Distribution of (T_n - 5hr T_n) in relation to T_n

T_n	(T_n - 5hr T_n) 0-0.5	0.6-1.0	1.1-1.5	1.6-2.0	2.1-2.5	2.6-3.0	3.1-3.5	3.6-4.0	Totals
- 3.6 to - 4.5	2	3	10	12	6	1	4		38
- 4.6 to - 5.5	1	2	9	8	3	2	3	2	30
- 5.6 to - 6.5	3	6	6	8	2				25
- 6.6 to - 7.5		3	5	3		2	1	1	15
- 7.6 to - 8.5	2	2	1	5	2				12
- 8.6 to - 9.5			1		1	1			3
- 9.6 to -10.5				1					1
-10.6 to -11.5						1			1
-11.6 to -12.5			1						1
-12.6 to -13.5				1					1
-13.6 to -14.5					1	1			2
Totals	8	16	33	38	15	8	8	3	129

4. Discussion

In Table 1, the distribution of the values in the individual lines suggests that a mean of all values may safely be used as an estimate of T_n - 3hr T_n. This is 1.2°C, equivalent to 2.1°F which may be conveniently rounded to 2°F.

Similar reasoning may be applied to the distribution in Table 2, which gives a mean value for T_n - 5hr T_n of 1.7°C, 3.1°F which may be rounded to 3°F.

This means that the lift may be reduced by 2°F if it is accepted that the design growing temperature may not be attained for short periods, not exceeding 3 hours. In practice the desired lift may be achieved because of the buffering effect of the heat within the house.

As an example, consider the values given for Filton in Agric. Memo 171. For heating in this district from February 15 onwards, safe T_n is given as 18°F, which leads to a 3hr T_n of 20°F and a 5hr T_n of 21°F. The only other adjustment necessary relates to the precise site of the glasshouse, if it is unduly liable to frost or particularly frost free. Clearly it is not possible to generalize on this, but the adjustment will probably not exceed 3°F and may frequently be nil.

5. Conclusions

Minimum temperatures used in the calculation of the temperature lift required in glasshouses may be raised by 2°F if it is acceptable that on occasion the required lift may not be reached for up to 3 hours. They may be raised by 3°F if this tolerance can be increased to 5 hours.

6. Acknowledgment

We are grateful to the staff of the Meteorological Office, Filton for the considerable help they gave us by extracting the data from their records.

7. Reference

Hogg W H. 1966. Minimum air temperatures for computing glasshouse heating requirements in the South West and West Midland Regions and in Wales. Agric. Memo No 171.

Any comments or suggestions on this paper should be sent to the authors.

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